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Economic evaluation of traffic safety measures for transport companies

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Abstract

This paper addresses the economic feasibility of measures to reduce the material damage of transport companies. Results are presented of a series of interviews among transport companies as well as from a postal questionnaire survey. Next, calculations are presented for three types of companies: a small family company, a large family company and a large formalised company. From the viewpoint of costs and benefits, damage prevention measures appear to be particularly interesting to larger companies. Small companies, being the largest group, tend to have an informal culture in which measures are less effective. Especially those measures for which no large investments are needed, which influence the behaviour of drivers and need not to be contracted out, are perceived as attractive by the transport companies.

Keywords: Transport companies; Damage prevention; Drivers

1. Introduction

Damage reduction often receives scant attention from transport companies, although costs of damage cases may be high. A damage case not only results in *direct* costs such as those of repair, but also in *indirect* costs: administration costs, costs for the temporary replacement of a truck, a negative image for a company, time costs of the driver and other employees, etc. During an interview it was suggested that these indirect costs may, on an average, be as high as the direct costs but transport companies are often unaware of these costs. The insurance company usually covers direct costs; this is not the case, however, for the indirect costs. In addition, companies that have a reduced damage frequency pay lower premiums than companies with a high frequency. Therefore, decreasing the number of damage cases may result in large cost cuts, which may be even larger than is directly shown in company accounts.

If a company wants to reduce its damage costs it may implement a wide range of measures, which, however, may result in other types of costs for the company. From an economic point of view, these measures should therefore be introduced when the cost savings are higher than the additional costs made.

The costs of high damage rates are not only high for companies, but also for society due to the connection with traffic safety. During an interview it was stated that approximately 2% of the reported damage cases by transport firms are accidents that have slightly injured people, 1% have seriously injured people, and 0.25% have been fatal accidents. Heyer and Wouters (1996) emphasise the societal advantages of fewer accidents as well; with every truck driver who is injured in an accident, six persons on average besides the driver are injured.

It can therefore be assumed that an active damage reduction policy will clearly have positive impacts on traffic safety in general. This may be an important reason for governments to encourage active damage prevention policies.

The high internal economic and external costs of damage cases raise the question of whether 'win–win'

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Table 1
Degree of introduction and average performance scores for various measures to reduce damage (1997)[a]

Measure	Costs	Resistance	Effectiveness	Introduced (%)
Formalised damage report	4.46	4.22	3.20	70
Discussion of damages in individual assessment talk	4.23	4.19	3.32	44
Individual feedback to drivers	4.14	3.93	3.44	52
Daily maintenance check by drivers	4.04	3.62	3.24	63
Computerised damage registration	4.00	3.99	3.21	45
Immaterial sanction	3.85	3.09	2.89	13
Material sanction	3.81	3.31	2.79	12
Selection of new personnel	3.78	3.76	3.30	58
Involving drivers in updating safety handbook	3.75	3.44	3.21	33
Immaterial reward	3.50	3.88	2.73	14
Damage prevention meeting	3.25	3.40	3.50	35
Material reward	3.15	3.99	2.95	17
Training new personnel	3.12	3.70	3.60	82
Tachograph analysis	3.12	3.70	3.09	10
Adaptation of premises	3.06	3.44	3.38	42
Trip planning	2.73	2.82	2.86	15
Side protection	2.58	3.25	2.97	12
Driving test	2.52	3.03	3.35	6
ABS	2.51	3.48	3.38	28
Safety course	2.41	2.84	3.11	13
Black box	2.34	2.96	2.86	21

[a] Average scores; respondents were asked to give a score varying from 1 (very high costs, very much resistance, very ineffective) to 5 (very low costs, very little resistance, very effective).

situations can occur, whereby companies can make profitable investments in damage reduction measures, and traffic safety for society overall is improved. In order to analyse this, our paper presents some indicative analyses of the costs and benefits from a firm's perspective to discover the extent to which measures are profitable for a firm. To find the necessary information for these analyses, a variety of interviews were held and a postal questionnaire survey was sent to transport companies. The results of this empirical research will be discussed first, and the results of the calculations will be presented afterwards. For a more detailed analysis, we refer to Lindeijer et al. (1997).

2. Results of the interviews

Based on interviews with an expert who advises companies in their damage reduction policies, 21 measures have been identified to reduce traffic damage (see Table 1). The first step towards the establishment of a damage reduction plan is to introduce the so-called *start model*. This three-part model consists of:

1. a formalised damage reporting system, with e.g. standardised forms and a central person to whom damage is to be reported;
2. a computerised damage registration system that uses a spreadsheet program or more sophisticated software;
3. individual feedback to the driver (e.g. a short talk and discussion per damage case).

This *start model* deserves priority above other measures, because if a company has no knowledge of problem areas, it makes no sense to introduce measures.

Next, six in-depth interviews have been held with companies varying in size and risk profile (i.e. types of trucks driven, type of goods carried, types of routes driven). All these companies had an active damage reduction policy. These interviews resulted in the following conclusions:

(1) The *start model* may have substantial effects on the number of damage cases, with reductions of up to 50%, depending on the damage frequency even *before* the model is implemented. The reasons are:

1. the attention to damage prevention makes drivers more conscious of the costs of damage reduction and the need/necessity to pay attention to this;
2. the management of the company gains insight into the damage patterns, frequencies, etc., and is therefore better qualified to introduce effective measures;
3. because of the measurement activities individual drivers or cases sometimes attract attention. In one company for instance, 20% of the drivers were involved in 80% of the damage cases. By giving these drivers particular attention, the damage frequency was lowered dramatically. In another company many accidents occurred at a specific crossing; by undertaking action there, the damage costs were significantly reduced.

(2) The introduction of the *start model* results in a reduction of the number of damages as well as in lower average costs per damage case. One company reports a reduction in the average amount per case and not in the frequency of damages.

(3) Additional measures are often decided in an ad-hoc way rather than after an analysis of possible benefits, costs and measures. These measures often aim to maintain the results at the current level by giving new attention to damage prevention.

(4) The company's culture – type of ownership, organisational structure, formal or informal management etc. – is often more important to the acceptance and introduction of measures than the monetary costs. Companies still owned by the founder or his family ('family companies') mostly have an informal style. In such companies the director's opinion is the most decisive factor of the introduction of a measure. In more formalised hierarchical companies implementation is easier.

(5) In many cases it is not the measure itself, but the psychological impact that is regarded as important. For example, a spirit of competition may develop among drivers. It is also significant that a measure be considered as 'fair' or 'reasonable'. Several companies emphasise the importance that a driver (or a small group of drivers) is responsible for his 'own' truck. The perceived attention of the management when introducing measures and the publicity surrounding damage reduction is extremely important for a successful implementation.

(6) The reasons for initiating damage reduction plans are mostly due to the high costs. A threat of a premium rise by an insurance company is important; a comparison of a company's own damage pattern with the national average, and a chaotic spiralling of damage costs are also significant. Other companies also mention image improvement as a reason.

(7) Technical measures such as ABS-systems (which avoid brake failures), a capsize warning system, and side protection are in almost all cases considered as too expensive if compared with expected cost reductions.

3. Results of the postal questionnaire survey

To obtain a broader picture of the damage reduction policies of companies as well as the impacts of the selected measures, a postal questionnaire survey was sent to about 500 companies in 1997. The useful response rate was 132 companies (26%). A wide range of companies have been included in the research population; these vary from companies having transport as a main activity, to companies which primarily transport their own goods between plants or to customers. The companies have been randomly chosen from members of various transport company branch organisations.

The questionnaire was divided into three sections:

1. Characteristics of the company: questions were asked regarding the size, the number of employees, the spatial scale of the market the company is serving, the type of goods carried, and the types of routes driven (fixed routes, variable routes).
2. Costs and effects of specific damage prevention measures: it was asked whether the measure is or will/might be introduced and to give a score varying from 1 to 5 on the costs, the expected resistance and effectiveness of the measures.
3. Opinions on statements regarding damage reduction policies and key success factors of such a policy.

3.1. Opinions regarding various measures

The scores for the introduction of various measures are presented in Table 1. The scales for costs, resistance and effectiveness have been defined in such a way that higher scores reflect a more favourable result.

The costs of the measures that have to be contracted out-driving skill test, safety course, tachograph analysis-are perceived to be high, while the first two are also difficult to introduce according to the respondents (see the scores for resistance). The costs of technical measures – ABS, black box, extra side protection, trip planning-are also thought to be high. Sanctions and rewards (monetary, non-monetary), maintenance check, and the inclusion of damages as an item in the yearly individual assessment talk are regarded as relatively inexpensive.

Most measures receive scores between 3 and 4 in response to the resistance against any particular measure in the organisation. The differences between most measures are not very large. The same holds true for the perceived effectiveness of measures. Most measures receive an average score between 3 and 4, which indicates that they are considered to be rather effective. The main exceptions are sanction and reward systems, which are thought to be less effective than the other measures. Note that material rewards encounter greater support than material sanctions; the same holds for immaterial rewards versus sanctions. Thus, it appears that sanctions are more difficult than rewards to bring into harmony with the business culture.

The set of measures most often implemented by the firms are the *start model*, extensive training of new employees by a company's personnel, and a daily maintenance check. The costs of training given by a company's own personnel are considered as somewhat high, but this measure is nevertheless assumed to be effective. More than 10% of the companies state that individual feedback, computerised damage registration, selection of new employees based on their 'damage history', damage cases in the yearly individual assessment talks, and computerised trip planning are being

Table 2
Share of respondents (in%) with a favourable cost-effectiveness and resistance-effectiveness rating

Measure	Cost-effectiveness	Resistance-effectiveness
Individual feedback to drivers	86	81
Formalised damage report	86	76
Discussion of damages in individual assessment talk	82	78
Computerised damage registration	72	69
Daily maintenance check by drivers	72	62
Selection of new personnel	65	65
Involving drivers in updating safety handbook	65	50
Immaterial sanction	59	32
Training new personnel	52	74
Damage prevention meeting	51	51
Material sanction	50	34
Immaterial reward	45	55
Tachograph analysis	43	55
Material reward	36	61
Adaptation of premises	31	55
ABS	22	57
Black box	22	49
Trip planning	22	33
Driving test	11	44
Side protection	10	49
Safety course	10	25

implemented in the course of 1997 (the latter information has not been included in the table).

In Table 2 the number of companies giving higher scores to effectiveness versus costs and resistance are presented. The scores have been computed as follows. For each respondent the rating for costs, resistance and effectiveness have been measured on a 5-point scale (see the note to Table 1). A respondent is considered to have a favourable cost-effectiveness rating when his/her rating for cost is higher than that for effectiveness (the scales for costs, resistance and effectiveness have been defined so that high scores reflect a good result). Resistance-effectiveness has been computed in a similar way.

The results presented in Table 2 lead to the conclusion that the *start model*, the involvement of damage patterns in individual assessment talks, and daily maintenance checks are perceived to be the most cost-effective. Technical measures (ABS, black box) and measures having to be contracted out (driving test, safety course) receive a low score. The results of the interviews (Section 2) confirm this finding.

When assessing the resistance-effectiveness it appears that once again the *start model* scores high, as do the yearly assessment talk and training of new personnel. Sanction schemes perform better than reward systems: this is no surprise since they meet with more resistance than reward schemes, whilst the perception of their effectiveness is about the same. The safety course and trip planning also receive a low score.

3.2. Other results

In addition to the questions related to the measures, respondents were asked other questions regarding damage prevention. Approximately 25% of the respondents have already established a damage reduction plan; most of these plans were written in the 1990s.

Table 3 shows the perception of firms concerning some key factors for a successful damage reduction policy. High scores are given to the involvement of drivers and management, followed by continuous attention to damage reduction in the company. The role of outside actors such as insurance companies and branch organisations is considered as less vital. According to the right-hand side of Table 3, the respondents have a positive attitude towards damage reduction policies.

It is valuable to know to what extent the number of damage cases per truck correlates with properties of firms such as its size (number of trucks), type of loads

Table 3
Scores on various key success factors and statements regarding damage reduction policies

Key success factors	Average score[a]	Statement	Average score[b]
Involvement of drivers	4.43	Does have effect	4.05
Involvement of management	4.23	My organisation is not too small	3.71
Permanent attention	4.08	Does not divert from key business	3.64
Enthusiasm of safety employee	3.87	Is not too time consuming	3.38
Quality information	3.86	Is important for image	3.31
Time available for safety employee	3.63	Results in cost reductions	3.05
Role of insurance company	3.39	Is important for quality and reliability	2.95
Role of branch organisation	3.18	Is important for relation with insurance company	2.90
		Results in lower fuel costs	2.45
		Improves working atmosphere	2.35
		Results in lower absence due to illnesses	2.11

[a] Scores asked vary from 1: very unimportant, to 5: very important.
[b] Scores asked vary from 1: totally disagree, to 5: fully agree.

Table 4
Rank correlations (Spearman's rho) between average number of damage cases (per year per truck) and various features of firms[a]

X1 Presence of prevention plan[b]	0.32**
X2 Number of trucks	0.35**
X3 Route variability[c]	−0.10
X4 Long distance orientation[d]	0.10
X5 Value density of freight[e]	0.18
X6 Full truck loads[f]	−0.39**

[a] N = 63
[b] X1 = 1 if prevention plan is available, X1 = 0 otherwise
[c] X3 = 1 if routes do not vary from day to day, X3 = 3 if routes vary from day to day, X3 = 2 intermediate case
[d] X4 = 1 local orientation, X4 = 2 regional orientation, X4 = 3 national orientation, X4 = 4: international orientation
[e] X5 = 1 bulk goods, X5 = 3 high value goods, X5 = 2 intermediate case
[f] X6 = 1 full truck loads, X6 = 0 Less than full truck loads.
** Correlation is significant at the .01 level (two-tailed)

carried, spatial orientation of markets, etc. Because several of these variables are only available as ordinal variables, we decided to compute rank correlations. The results are presented in Table 4.

From this analysis it can be concluded that companies having a damage reduction plan have on average more damage cases than companies without such a plan. Having many damage cases apparently provides an incentive for preparing and introducing a plan, but such a plan has not (yet) reduced the number of cases below the average of all companies. Another effect may be that firms with a damage reduction plan have as a result a better damage registration and hence they report more damage cases.

As also appeared from the interviews, the size of the company measured in number of trucks has a positive correlation with the number of damage cases. A more hierarchical and formal structure with less driver commitment may be the explanation for this.

Companies that usually have full truck loads generally report fewer damages than companies transporting less than full loads. This may be explained by the notion that this type is for distribution trips: speed then becomes more important. Another result is, however, that companies primarily driving fixed routes do not encounter fewer damage cases than companies driving alternate routes, although the expectation was that this was the case. The same holds for the value density of freight: one might expect this group to be more in a hurry, thus potentially leading to more damage cases. A notorious transport category in the Netherlands is the (international) transport of flowers by truck. This transport takes place within tight deadlines and these truck drivers have the reputation that they systematically ignore speed limits in order to deliver the flowers on time.

4. Impacts of the measures

The above analysis is based on qualitative data concerning the perceptions of entrepreneurs. To give a more precise indication of the costs and benefits of damage prevention measures, we made a selection of 10 promising measures mainly based on Tables 1 and 2. In the remainder of the paper these measures will be discussed and the impacts, costs and benefits will be calculated. Before turning to the actual calculations, it is first necessary to define in further detail some ideal types companies for which these calculations will be made and give a more succinct indication of the impacts of various measures.

From the interviews and the postal questionnaire it appeared that internal economic costs and benefits depend on specific characteristics of a company. It is for example important that positive incentives are given repeatedly; the behaviour and attitude of the management is also important. In this way the culture of the company is regarded as a key success component (see also Misumi, 1978; Peters, 1991; Endsley, 1995a,b; Gregersen, 1995). Another relevant result of the analysis above-which is reconfirmed by insurance companies-is that the size of the company is important for the number of damage cases (cf. also Lindeijer, 1995).

It is, therefore, impossible to present unique figures that are applicable to each individual company. Three company types, which are fairly representative for all companies, are outlined below. Each type differs widely in size and company culture. To reduce the complexity of the analysis, no further distinction is made between other characteristics of a company, because these characteristics are too specific and differ broadly across companies. They can be described as follows.

4.1. Company A: small family company

Company A is a small family company managed by the founder or family of the founder. The company started with just one truck, and slowly grew; now there are many more drivers and family members working for the company. The working environment is informal and the company is non-hierarchically organised. As a result, the employees know 'everything' about each other (driving style, driving behaviour, number of damages), but it is 'not done' to criticise colleagues. The commitment of employees to the company is high. The company is assumed to have ten trucks and ten drivers; more personnel are employed for other tasks. The damage frequency is quite low and is about 0.5 cases per truck/driver per year.

4.2. Company B: large family company

Company B is a large version of Company A. The founder is the director of the company and the informal working environment and non-hierarchical organisation are still present. The company has however, grown considerably over time; therefore the social involvement and cohesion are smaller than in Company A. Company B owns 50 trucks and has 50 drivers. The damage frequency is 0.75 cases per truck/driver per year.

4.3. Company C: large formalised company

Company C has an entirely different company culture: relations among employees are hierarchical and strongly formalised. Management does not know its employees very well, and there is an intermediate management level. The commitment of the drivers to the company is small; the same holds for the social cohesion of the drivers. The damage frequency on the other hand, is rather high. The company owns 100 trucks and employs 100 drivers. The average damage frequency is higher than in the previous companies: 0.9 per truck per year.

After the definition of the company types we now turn to the impacts, i.e. the level of damage reduction per measure, of a measure for each company type. Based on a literature review (references are given below), and supplemented with the results of the various interviews, it is possible to estimate the impacts of the selected measures per company. We will analyse the maximum effects: in practice, the effects are probably smaller because of implementation problems or specific features of a company. Given the lack of studies in this area upon which parameter values can be based, one should not attach an overly strict meaning to the figures presented below. They give only an indication of a possible order of magnitude of cost–benefit balances.

4.4. The start model

From the interviews it was revealed that the introduction of the *start model* may result in a damage reduction of up to 50%. Furthermore, it appeared that giving individual feedback to the drivers is most difficult to introduce, because it costs the most time and causes the greatest resistance. As a consequence, this part of the *start model* is the least introduced. It may be assumed that the start model without giving individual feedback also has a positive impact on damage reduction (Chhokar and Walin, 1984). It is assumed for pragmatic reasons that in this case the reduction of the number of damages is 25%.

Due to the company culture and the fact that the management knows its personnel, it is assumed that this model will have no impact in Company A. So the effects of 50% or 25% only hold for Companies B and C.

4.5. Damage prevention meetings, driving tests and reward/sanction schemes

Gregersen (1995) investigates the impact of behavioural measures on the reduction of damages in transport firms. The largest impact is found for group discussions (54%; this is assumed to be the maximum impact of damage prevention meetings), followed by driving tests (34%) and reward schemes (lower, but no percentage is reported). Based on the research of Bruce-McAfee and Winn (1989), the impact of sanction and reward schemes is assumed to be 25%. The latter schemes should be adapted to the company's culture however; otherwise these will not be very effective and will merely cause considerable resistance (Kipping, 1989).

Damage prevention meetings are designed to improve social cohesion, while both other measures may be assumed to compensate for the lack of commitment or social cohesion. Therefore, these measures are again assumed to have no impact in Company A.

4.6. Yearly assessment talks and tachograph analysis

As is the case with the driving tasks, these measures aim to influence and control driving behaviour. It is assumed that the impact of these measures is about equal to the impacts of the driving tests (34%) when these tests are repeated periodically (annually). However, in many cases these measures may only be introduced incidentally, for instance, after a serious damage case or accident. The measures acquire the character of a sanction; it is assumed therefore, that the incidental measures will have the same impact as sanction schemes (25%).

4.7. Selection personnel, maintenance check, drivers' handbook

These measures do not impact at the individual level, their aim is to influence the behaviour of the entire group of drivers. Therefore, there is only a general reduction impact. This effect will not be very important in practice as was frequently mentioned in the interviews: the maximum effect is said to be 2%. For a comparable measure, Twisk (1993) finds a similar effect. Because of the company's culture, this measure is assumed to have no effect in company A.

We assume that a company in all cases introduces the *start model* (with or without individual feedback). Next, it is assumed that one of the other measures is introduced. The other measures therefore have an additional effect based on a lower reference value for the damage frequency.

Table 5
Calculation of costs: one damage case

Average costs	$1500
Repaid by insurance companies	−$750
Indirect costs	+$750
Raise in premium insurance company	+$375
Total costs	$1875

5. Cost–benefit analysis for the distinct companies

When calculating the costs of a measure, a distinction has been made between direct and indirect costs (see Section 1) as well as initial (once-only), fixed (yearly), and variable (depending on the number of damage cases) costs. Various assumptions have been made, e.g., regarding the time required to implement the measure, which certainly influences the outcome of the calculations. The main issues are:

- the method of *implementation*; how much time is needed to implement the measure, what are the investment costs (e.g. material), is contracting out or external advice necessary, etc.;
- the *availability* of resources; for example, can computerised registration use existing computers and software?, is there a maintenance unit?;
- to which extent *do economies of scale* occur? Measures with high fixed investment costs are more attractive for large rather than for small companies.

To calculate the benefits of the measures, certain assumptions have to be made. Based on information provided during the interviews, the average cost per damage case is $1500[1]. Based on the analysis in Table 5, the total benefit to a company for a reduction by one damage case is $1875.

We will not elaborate here on the specific costs and benefits of the calculations (see Lindeijer et al., 1997), but instead present the results (Table 6). For Companies B and C all measures are economically profitable except 'maintenance check'. The latter is caused by the large time costs: it is assumed that it takes two minutes per driver per day. Although this seems like a short time period, it is equal to a labour input of 7 h per year. Given the high labour costs in the Netherlands, this may be too high to make it a profitable damage reduction measure. In practice, however, these costs may not be thought to be as high as these calculations indicate. Other measures with rather low benefits involve drivers in writing the handbook and the selection of personnel based on 'damage history'. For the other measures, the benefits are so high that other assumptions regarding the costs and benefits/effects will lead to positive results unless the assumptions differ widely.

It must be emphasised, however, that the calculations are based on maximum effects of a measure. In reality the benefits are likely to be smaller. It is therefore interesting (by means of a sensitivity analysis) to evaluate the benefit–cost ratios of the various measures. This also allows for a comparison with other investment possibilities (Table 7).

The benefit–cost ratio clearly shows that when the impact is, for example, half as large (roughly resulting in 50% lower benefits), most measures are still profitable. The results are therefore quite robust.

It is important to note that a combination of various measures will reduce the benefits: with the present figures it is assumed that the measure is the only one in addition to the *start model*. When more measures are introduced, the benefits will decrease.

Table 6
Benefit-Cost balance of damage prevention measures (USD per year; maximum effects)[a]

Measure	Company				
	A	B+[b]	B–[b]	C+[b]	C−[b]
Start model	-/-750	15 594	7182	81 391	39 493
Sanctions and rewards	-/-186	17 568	20 380	27 393	42 580
Indiv. assessment talk	-/-80	17 885	20 698	27 895	43 082
Prevention meetings	-/-692	26 060	30 279	40 343	63 968
Driving test (incidental)	2121	12 243	14 353	19 705	29 830
Driving test (periodical)	955	8235	11 048	10 828	26 015
Tachograph analysis (incidental)	2194	12 206	14 173	19 980	35 875
Tachograph analysis (collective)	2188	13 781	16 594	20 688	35 875
Drivers' handbook	-/-185	1037	1037	1225	2913
Selection personnel	-/-32	1248	1248	1371	3058
Maintenance check	-/-634	-/-1765	-/-1765	-/-4,655	-/-2,967

[a] In the calculations it is assumed that the measure is the only one which is introduced in addition to the start model.
[b] B− and C− have introduced the start model without individual feedback, B+ and C+ have introduced the model including individual feedback.

[1] The initial calculations were in Dutch guilders. Here an exchange rate of 1 USD = 2 DFL is used.

Table 7
Cost ratio of damage prevention measures (USD per year; maximum effects)[a]

Measure	Company				
	A	B+[b]	B−[b]	C+[b]	C−[b]
Start model	–	8.86	5.46	28.73	15.78
Sanctions and rewards	–	25.6	29.54	22.15	33.88
Indiv. assessment talk	–	46.11	53.20	36.18	55.33
Prevention meetings	–	10.41	11.94	8.73	13.26
Driving test (incidental)	10.49	11.97	13.85	9.83	14.36
Driving test (periodical)	1.43	1.82	2.10	1.61	2.46
Tachograph analysis (incidental)	15.63	11.58	11.93	11.21	11.73
Tachograph analysis (collective)	3.19	4.06	4.69	3.59	5.84
Drivers' handbook	–	3.80	3.80	3.65	7.30
Selection personnel	–	8.87	8.87	5.32	10.65
Maintenance check	–	0.44	0.44	0.27	0.53

[a] In the calculations it is assumed that the measure is the only one which is introduced in addition to the start model. The figures can be interpreted as follows: a yearly cost of $1 for introducing an individual driving test by company A generates $10.49 as benefit (minus costs).
[b] B− and C− have introduced the start model without individual feedback, B+ and C+ have introduced the model including individual feedback.

From the calculation method, it follows that Companies B and C, which introduced the *start model* without individual feedback, benefit more from the other measures than the companies that introduce individual feedback. This is caused by the larger impact of the full *start model*; therefore there are fewer damage cases 'left' for the other measures. But when both amounts are added (i.e. of the measures and the *start model*), the total benefit is always larger than that which includes the full start model.

For Company A many fewer measures appear to be profitable. Some measures are assumed to have no impact whatsoever for this measure, and so there are no benefits included in the calculations. Only driving tests and tachograph analyses have an effect on the number of damage cases.

6. Conclusions

From the viewpoint of costs and benefits, damage prevention measures are mainly interesting to larger companies. As the largest group, small companies normally have an informal culture in which measures are less effective. The measures that are perceived as the most attractive by the transport companies do not require large investments, they need not be contracted out, and they tend to modify the behaviour of drivers in a safety-oriented way. This is no surprise because the costs and the risks are quite low.

Final remarks must be given on the calculations presented above. The impacts of the measures are largely related to how they are implemented. An assortment of subjective factors such as the company culture and the involvement of the management play an important role in this respect. The calculations also assume a maximum effect; in practice, the actual effects will probably be lower. However, the benefit–cost ratios show that even when the effects are not maximal, there may still be high benefits.

The study shows that companies with an active damage reduction policy can achieve substantial benefits and operate in a more profitable way. Additional impacts may also be achieved:

- the atmosphere at the company may improve (e.g. more commitment from drivers, fewer absences from illness). This may in turn have positive impacts on the functioning of the company as well;
- the image of a company may improve because there is less bad news about it;
- there may be additional savings in maintenance costs because more careful driving styles are applied.

In this way, positive and self-reinforcing impacts may occur, thus resulting in high indirect benefits of damage prevention policies.

One of the most striking results of this research is that companies seldom register damage cases systematically; in even fewer cases individual feedback is given to drivers. Only by introducing the 'start' model will large benefits for a company result. This will mainly be due to a cultural and psychological shift stemming from the attention dedicated to damage prevention, and possibly from giving solutions for specific cases. When introducing this so-called 'start' model, damage reductions of 50% are sometimes recorded.

An important social benefit is that the number of accidents will reduce. Consequently, social benefits will even be larger than the internal ones of the firm.

This may be an important reason for governments to urge companies to participate in damage reduction programmes. The introduction of the *start model* may be an important step.

It has been shown that substantial benefits are likely to be achieved especially in larger companies through the implementation of active damage reduction strategies. This may also result in the improvement of traffic safety in general.

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